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Research Article

A Comparative Study on Physical Function Test between Faller Group and Nonfaller Group among Community-Dwelling Elderly

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SUMMARY

Purpose: This study aimed to identify the physical function test differences between the faller group and the nonfaller group in a sample of the community-dwelling elderly.
Methods: This study used a nonexperimental two-group-comparative study design. The participants were 356 people aged 65 years and over living in an urban area. From May to December 2010, data were collected through personal interviews using questionnaires and measurements of muscle strength, physical endurance, flexibility, motor agility and dynamic balance, and static balance. The collected data were analyzed by descriptive statistics, Chi square analysis, and *t* test.
Results: Upper muscle strength was significantly weaker in the faller group ($p < .05$). Lower muscle strength was significantly weaker in the faller group; both hip flexion ($p = .004$), knee extension (Right: $p = .004$; Left: $p = .031$), left ankle plantar flexion ($p = .045$), and left ankle inversion ($p = .036$). Tandem standing with eyes opened and closed was significantly shorter, indicating decreased static balance in the faller group.
Conclusion: Nurses should make efforts to implement exercise programs focused on physical fitness enhancement for community-dwelling elderly adults for fall prevention.

Introduction

The occurrence of falls frequently leads to injuries among the elderly requiring medical attention and rehabilitation (Carroll, Slattum, & Cox, 2005). A fall can be defined as an inadvertent coming to rest on the ground or a lower level (Stalenhoef, Diederiks, Knottnerus, Kester, & Crebolder, 2002). It is experienced by most people at least once during their lifetime. While this may seem like a trivial occurrence, falls by the elderly significantly impact morbidity and mortality rates by causing injury, hospitalization, premature death, impaired mobility, and more (Roe et al., 2009). The reported rate of falls from 6–25% (Hong, Cho, & Tak, 2010; Lim, Park, Oh, Kang, & Paik, 2010; Pluijm et al., 2006), and the incidence of injurious falls is higher in people aged over 65 years (Hong et al.).

Along with the physiological changes caused by aging, the elderly experiences pain from chronic ailments, difficulty in walking, joint deformation, and a decline in their sense of balance, which renders them highly susceptible to the dangers of falling (Aslan, Cavlak, Yagci, & Akdag, 2008; Jung, Lee, & Chung, 2006). One fall experience heightens the risk of subsequent falls (Pluijm et al., 2006). Those who experience recurrent and habitual falling are reported to have diverse differences in physical function (PF), including diminished dynamic response (Choi, Lim, & Jun, 2007), decreased gait stability, and variation in joint angles (Kim & Shin, 2005), in addition to the physical changes related to normal aging.

The occurrence of falls is related to various risk factors. In terms of physical function, they include poor strength with a feeble grip, (Choi et al., 2007; Hong et al., 2010; Pluijm et al., 2006; Sipilä et al., 2006), poor range of motion and flexibility (Chiacchiero, Dresely, Silva, DeLosReyes, & Vorik, 2010), an abnormal sense of balance and walking (Chang & Kang, 2004; Chiu, Au-Yeung, & Lo, 2003; Jung et al., 2006; Melzer, Benjuya, & Kaplanski, 2004; Wallmann, 2001), abnormal postural swaying (Stalenhoef et al., 2002), lower-body instability (Tinetti, Speechley, & Ginter, 1988), mobility problems (Halil et al., 2006; Jung et al.), functional limitations (Pluijm et al.), and delayed reaction time (Choi et al.). A nursing intervention strategy for reinforcing the aspects of PF is warranted to prevent and reduce the occurrence of falls among the elderly.

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However, even though numerous research have reported the improvement in PFs and the effect in lowering the occurrence of falls after using fall-prevention nursing intervention strategies (Bird, Hill, Ball, & Williams, 2009; Lee, An, & Jung, 2010), other studies have also revealed no effects at all (Logghe et al., 2009; Vind, Andersen, Pedersen, Jorgensen, & Schwarz, 2009). The reason for such mixed results is because the fall prevention-related factors were not fully reflected in the fall-prevention programs, or only fragments or parts of the PFs were evaluated. Previous studies did not evaluate various PFs from multi-dimensional aspects; thus, it is necessary to develop nursing intervention strategies suitable for Koreans in terms of PF. From a nursing perspective, there is also an urgent need to develop and apply nursing intervention programs that are tailored to fallers by using detailed comparative analysis to identify clearly the differences in the PF test of fallers. The purpose of this study were to identify the PF test differences between the faller group and the nonfaller group in a sample of the community-dwelling elderly.

Definitions

A “fall” was described theoretically as an inadvertent coming to rest on the ground or a lower level (Stalenhoef et al., 2002). In the current study, the fallers were defined as subjects who unintentionally descended or slipped down to the ground or a lower level within 1 year. The nonfallers, however, were defined as not having any experiences of fall.

Physical function

PF was theoretically defined as ability to take part in basic activities of daily living independently (Katz, Ford, Moskowitz, Jackson, & Jaffee, 1963; Lee & Oh, 2003). In the current study, PF referred to the numeric score of the level of muscle strength, physical endurance, motor agility and dynamic balance, and static balance.

Methods

Study design

A nonexperimental two-group-comparative study design was used to identify the PF test differences between the faller group and the nonfaller group in a sample of community-dwelling elderly.

Sample and data collection

Prior to data collection, the research was approved by the institutional review board of related universities. Participants were recruited from among the elderly who visited the local health care centers located in the southern region of Seoul and Y city of Gyeonggi-do from May to December 2010.

Data on their fall experiences were obtained by self-reported answers. Participants of most preceding studies were those who had experienced falls more than once a year based on self-reported answers (Aslan et al., 2008; Chung & Choi, 2009; Jung et al., 2006). The accuracy of fall recalls was reported to be as high as 84% (Mackenzie, Byles, & D’Este, 2006). As such, this method was also applied to the present study. Data were collected through researcher-administered questionnaires and measurements of PFs at the health education rooms in the local health care centers.

It took approximately 1.5 hours for each person to complete the questionnaire and PF test. Because all participants were the elderly, it took a relatively long time to explain the process and method of measuring their PFs, and to ask for cooperation to measure them accurately. At the same time, most of the elderly carefully listened to the explanation and fully participated in the research.

The inclusion criteria were, (a) elderly men and women aged over 65 years and who understood the purpose of the study and consented to participate, (b) individuals who have recently experienced falls more than once a year, (c) individuals with a Mini-mental state examination score $\geq$ 24 (cutoff based on education and age), (d) individuals capable of communication and in possession of mental clarity, and (e) individuals capable of walking independently and performing activities of daily living without an aid.

At the local health care centers where the elderly visited, the researcher explained the purposes of the study to the potential participants, requested their cooperation, and recruited 427 individuals who completed a written consent form. Among them, 21 individuals gave insufficient responses or were unable to perform independent activities of daily living and 10 individuals with missing PF test data were excluded, leaving a final sample of 356 participants.

The research supervisor and four research assistants (all with a master’s degree or higher and had received training on the chosen survey and PF test methods) personally visited the local health care centers. We used a structured questionnaire to collect data using one-on-one survey administration and PF test sessions to minimize the margin of error in the results of PF tests.

Prior to this study, the researchers and research assistants had sufficient discussions on the measurement method in order to minimize the margin of error by applying a consistent method. To secure reliability, we continued to measure until no errors were evident, and we then implemented the PF test. Based on previous research (Choi et al., 2007; Lim & Lee, 2001), the researchers recorded the higher of the two sets of results obtained.

Measures

The demographic characteristics included age, gender, residential status, number of diseases, number of medications, and exercise habits. Information related to fall occurrences in participants included frequency, time, place, cause of fall, fall behavior, fall injury and its types, treatment and so on. Specifically, the PF (muscle strength, physical endurance, motor agility and dynamic balance, static balance) differences between the faller and nonfaller groups were evaluated.

Muscle strength

Muscle strength of the upper and lower bodies was evaluated using the Lafayette Manual Muscle Tester (MMT, model 01163; Lafayette Instrument Company, Lafayette, IN, USA). Using kilograms, the manual muscle tester reported the flexion and extension of the elbow joint, hip joint, knee joint, and the planter flexion, inversion, and eversion of ankle joint during movement in the right and left directions. For elbow flexion and extension tests, the subject’s arm was flexed to 90 degrees while an examiner stabilized the elbow. The MMT was placed inside the palm on which four fingers were placed horizontally. Next, the subject was instructed to pull or push the arm fully. For the hip flexion test, the subject was seated on a chair with folded arms. The MMT was placed on the knee from which four fingers were placed horizontally and the subject was instructed to flex the leg towards the body. For the hip extension test, the subject stood with both hands against the walls. The MMT was placed in the back of the knee from which four fingers were placed horizontally and the subject was instructed to kick his or her leg backwards without bending the knee. For the knee flexion and extension tests, the subject was seated in a chair while the examiner stabilized the knee while not being lifted. The MMT was placed on the area between the inner part of the ankle (Achilles tendon) and the outer part of the ankle (top side of the foot) on which four fingers were placed horizontally. Next, the subject was instructed to pull his or her foot backwards. For the ankle plantar flexion test, the subject was seated on a chair with his or her shoes taken off and instructed to stretch the legs and hold them in the air with the ankles supported by the examiner. The MMT was placed on the ball of the foot—just below the toes—and the subject was instructed to push his or her foot down towards the ground. For the ankle inversion and eversion tests, the subject was seated in the same posture as for the ankle plantar flexion test, and the MMT was placed on the sides of the big toe and the little toe. The subject was then instructed to turn his or her foot inwards and outwards, respectively.

Physical endurance

Physical endurance was evaluated through the Senior Fitness Test (SFT). The SFT, developed by Rikli and Jones (1999) and translated by Kim and Park (2005). This instrument's test-retest reliability was .80–.98 (95% confidence intervals = .79–.98), and this instrument is reported to be safe in evaluating the community-dwelling elderly (Rikli & Jones). In the SFT, physical endurance was evaluated using a 2-minute step test. While standing up straight, the participant was required to raise each knee alternately up to a level between the patella and the iliac crest. The number of steps taken was measured, counting only those times when the right knee reached the specified height.

Flexibility

Flexibility was measured using the SFT, separately for the upper and the lower body. The Back Scratch test was used for assessing upper-body flexibility. The participant reached one hand over their shoulder and the other around the waist toward the middle of the back, and the distance between the two extended middle fingers was measured in centimeters. To measure lower-body flexibility, the Chair Sit-and-Reach test was used. The participant sat with one leg extended forward, reaching both hands toward their toes, and the distance from the extended fingers to the toes was measured in centimeters.

Motor agility and dynamic balance

Motor agility and dynamic balance were evaluated using the 244 cm Up-and-Go category of the SFT. On signal, the participant was required to get up from a chair, walk as quickly as possible for a distance of 244 cm around a designated target, and return to sit on the chair. The time needed to complete this action was measured in seconds.

Static balance

To assess static balance, tandem stand and one-leg stand were administered with the participant's eyes opened and closed to see how long they could maintain a balanced posture (Melzer et al., 2004; Schoenfelder & Rubenstein, 2004).

For the tandem stand, the participant stood up with his or her feet placed front-to-back, the heel of one foot touching the toes of the other. This posture was maintained for as long as possible. The test ended when either foot moved or lifted from the ground, and the time up to that point was measured in seconds. For the one-leg stand, the participant was instructed to stand on one leg with the other leg was lifted. This posture was maintained for 20 seconds. Time was measured in seconds from the moment the nonstanding leg was lifted from the floor, and stopped when the two legs came into contact or the lifted foot touched the floor before the 20 seconds were over.

Data analyses

The data were statistically analyzed using SPSS version 15.0 for Windows (SPSS Inc., Chicago, IL, USA), with the level of significance set at $p < .05$. For differences in the general characteristics of participants between the faller group and the nonfaller group,

Table 1 *Comparison of Demographic Characteristics of Faller Versus Nonfaller*

Variables	Categories	Faller ($n = 99$)	Nonfaller ($n = 257$)	Total ($n = 356$)	χ^2	p
		n (%)	n (%)	n (%)		
Gender	Male	23 (23.2)	96 (37.4)	119 (33.4)	6.41	.011*
	Female	76 (76.8)	161 (62.6)	237 (66.6)		
Age (yr)	65–70	46 (46.5)	128 (49.8)	174 (48.9)	0.38	.984
	71–75	32 (32.3)	79 (30.7)	111 (31.2)		
	76–80	15 (15.2)	35 (13.6)	50 (14.0)		
	≥ 81	6 (6.1)	15 (5.9)	21 (5.9)		
Residential status	Detached house	10 (10.1)	57 (22.2)	67 (18.8)	8.72	.033*
	Apartment	68 (68.7)	141 (54.9)	209 (58.7)		
	Villa, town house, multiplex house	16 (16.2)	50 (19.5)	66 (18.5)		
	Other	5 (5.1)	9 (3.5)	14 (3.9)		
No. of diseases	0	4 (4.0)	16 (6.2)	20 (5.6)	4.72	.193
	1	13 (13.1)	48 (18.7)	61 (17.1)		
	2–3	42 (42.4)	117 (45.5)	159 (44.7)		
	4–5	27 (27.3)	49 (19.1)	76 (21.3)		
	≥6	13 (13.1)	27 (10.5)	40 (11.2)		
No. of medications	0	5 (5.1)	22 (8.6)	27 (7.6)	11.91	.008*
	1	20 (20.2)	92 (35.8)	112 (31.5)		
	2–3	55 (55.6)	114 (44.4)	169 (47.5)		
	≥4	19 (19.2)	29 (11.3)	48 (13.5)		
Exercise	Yes	75 (75.8)	207 (80.5)	282 (79.2)	1.00	.319
	No	24 (24.2)	50 (19.5)	74 (20.8)		

*$p < .05$.

numbers, percentages, and the χ^2 test were used. For information related to falling obtained from the faller group, real numbers and percentages were used. For differences in the PF test of participants between the faller group and the nonfaller group, $M \pm SD$ and the t test were used.

Results

Comparison of demographic characteristics of fall experiences

Among the demographic characteristics, gender, age, residential status, number of diseases, number of medications, and exercise habits were examined for differences between the faller and nonfaller groups (Table 1). The average age was 71.6 ± 4.9 years. Analysis of these demographic characteristics showed statistically significant differences between the two groups in the categories of gender, residential status, and number of medications. There was no statistically significant difference between the types of medication and falls between the two groups.

Information related to falls

Examination of the fall-related information obtained from the faller group revealed that 27.8% of the participants had experienced a fall in the past year, and 87.9% experienced it once or twice. Falls most commonly occurred in winter (28.4%), in the afternoon (61.4%), and in a room (43.8%). Slippery or uneven floor was the biggest cause of falls (26.3%). The largest number of participants, 58.1% of the faller group, reported having fallen while walking and 70.1% had suffered in juries because of falling (Table 2).

PF test

Comparison of muscle strength

When the upper-body muscle strength measurements between the two groups were compared, the flexion ($t = -3.26$, $p = .001$; $t = -3.29$, $p = .001$) and extension ($t = -4.22$, $p < .001$; $t = -3.39$, $p = .001$) of the elbow joint in the right and left directions (as measured with the MMT) all showed statistically significant differences. This demonstrates that the faller group had weaker upper-body muscle strength than the nonfaller group.

When comparing lower-body muscle strength using the MMT, right and left hip flexion ($t = -2.86$, $p = .004$; $t = -2.89$, $p = .004$), right and left knee extension ($t = -2.26$, $p = .024$; $t = -2.16$, $p = .031$), left ankle planter flexion ($t = -2.01$, $p = .045$), and left ankle inversion ($t = -2.11$, $p = .036$) were found to be statistically significant. The data indicated that the faller group was inferior to the nonfaller group in terms of muscle strength in both hips and both knees, and in their capacity for left ankle planter flexion (Table 3).

Comparison of static balance

In terms of static balance, the Tandem Stand category produced statistically significant differences when both eyes were open ($t = -2.23$, $p = .028$) and when they were closed ($t = -2.84$, $p = .005$), indicating that static balance was lower in the faller group than in the nonfaller group (Table 4).

Table 2 *Characteristics of Falls among Elderly Fallers (N = 99)*

Variables		Categories	Fall n (%)
No. of falls in previous year		1–2	87 (87.9)
		≥3	12 (12.1)
Time of fall occurrence[a]	Season	Spring	35 (23.6)
		Summer	39 (26.4)
		Autumn	32 (21.6)
		Winter	42 (28.4)
	Time	Dawn	6 (3.9)
		Morning	39 (25.5)
		Afternoon	94 (61.4)
		Evening	14 (9.2)
Place of fall[a]		Living room	4 (25.0)
		Room	7 (43.8)
		Toilet, bathroom	4 (25.0)
		Kitchen	1 (6.3)
Cause of fall[a]		Dizziness	12 (7.7)
		Loss of balance	20 (12.8)
		Falling objects hanging	28 (17.9)
		Slippery floor	41 (26.3)
		Misstep	26 (16.7)
		Bumped	7 (4.5)
		Other (without reason, sudden loss of strength on the legs)	22 (20.6)
Behavior of fall[a]		Walking	90 (58.1)
		Running	4 (2.6)
		Standing	4 (2.6)
		Climbed and descended the stairs	26 (16.8)
		Changing in posture	5 (3.2)
		During exercise	7 (4.5)
		while at work	5 (3.2)
		Other (occupied rest room, riding a bike, mountain climbing)	14 (9.0)
Fall injury[a]		Yes	110 (70.1)
		No	47 (29.9)
Injured after fall[a]		Head, face	11 (10.0)
		Chest, abdomen	7 (6.4)
		Pelvic, Supine	8 (7.3)
		The upper limbs	15 (13.6)
		The lower limbs	63 (57.3)
		Declined to answer	6 (5.5)
Injured type[a]		Fracture	19 (17.3)
		Sprain	30 (27.3)
		Contusion	10 (9.1)
		Abrasion	29 (26.4)
		Other (contusion, myalgia, desmorrheixs, tooth fracture, epistaxis)	7 (6.4)
		Declined to answer	15 (13.6)
Fall treatment[a]		Hospital treatment	56 (36.1)
		Take medicine	28 (18.1)
		Folk remedies	6 (3.9)
		Neglect	55 (35.5)
		Other (health center, Oriental medical clinic, self-treatment)	10 (6.5)

[a] Multiple responses.

Discussion

This study compared the general characteristics of fallers and nonfallers and revealed that the two groups had significant differences in terms of gender, residential status, and number of medications taken. The frequency of falls occurred more often among women than among men. This finding supports the results of earlier studies concluding that the incidence of falls in elderly women was higher than in elderly men (Carroll et al., 2005; Halil et al., 2006; Yoo & Choi, 2007). This suggests that being a woman itself is a risk factor for falling. Aged women fall more often, suffer serious consequences, have a greater fear of falling, and subsequently experience restrictions in activities (Lim et al., 2010).

This gender-based difference in fall rates is thought to stem from women's exposure to more opportunities for falling. Elderly women continue to participate in everyday activities by performing housework, shopping, taking care of grandchildren, and so on,

Table 3 *Muscle Strength of Upper and Lower Body*

Variables	Test items	Side	Faller ($n = 99$) M (SD)	Nonfaller ($n = 257$) M (SD)	t	p
Upper body	Elbow flexion (kg)	Rt	10.98 (3.87)	12.58 (4.71)	−3.26	.001*
		Lt	10.66 (3.70)	12.21 (4.58)	−3.29	.001*
	Elbow extension (kg)	Rt	7.28 (3.05)	9.01 (4.31)	−4.22	.000*
		Lt	7.32 (3.33)	8.74 (3.96)	−3.39	.001*
Lower body	Hip flexion (kg)	Rt	13.74 (4.32)	15.36 (4.91)	−2.86	.004*
		Lt	13.33 (4.38)	14.98 (4.95)	−2.89	.004*
	Hip extension (kg)	Rt	11.25 (3.72)	12.19 (4.08)	−1.95	.052
		Lt	11.33 (3.75)	12.05 (4.07)	−1.51	.132
	Knee flexion (kg)	Rt	12.31 (3.88)	12.98 (4.11)	−1.39	.166
		Lt	12.23 (3.93)	12.90 (4.05)	−1.39	.166
	Knee extension (kg)	Rt	13.84 (4.19)	15.11 (4.88)	−2.26	.024*
		Lt	13.12 (4.47)	14.24 (4.68)	−2.16	.031*
	Ankle plantar flexion (kg)	Rt	10.23 (4.01)	11.22 (5.22)	−1.89	.060
		Lt	10.12 (4.29)	11.33 (5.34)	−2.01	.045*
	Ankle inversion (kg)	Rt	5.92 (2.50)	6.40 (2.56)	−1.58	.115
		Lt	5.66 (2.17)	6.28 (2.54)	−2.11	.036*
	Ankle eversion (kg)	Rt	6.15 (2.45)	5.69 (2.69)	.945	.346
		Lt	4.96 (2.16)	5.19 (2.35)	−.822	.421

Notes. Rt = right; Lt = left.
*$p < .05$.

whereas retired elderly men lead relatively inactive lives by engaging in religious activities and get-togethers with friends (Halil et al., 2006). Therefore, it is particularly important to inform elderly women of the fall risks related to various activities and provide them with education on fall prevention. The elderly should also be offered different fall-prevention intervention approaches based on gender and gender roles.

There were statistically significant differences not in the types of medications taken by fallers and nonfallers, but in the number of medications. In the fall group, participants who were taking 2–3 separate medications showed the highest frequency of falls. This result was congruent with previous studies, which reported polypharmacy as a significant risk factor of fall (Baranzini et al., 2009; Lee, Hui, Chan, Chi, & Woo, 2008; Sterke, Verhagen, van der Beeck, & van der Cammen, 2008). However, Jung and colleagues (2006) reported that in the community-dwelling elderly, there were no statistically significant differences between the number of medications and fall experience. In another study on fall experiences and the use of medication, the elderly who were on medication had a higher rate of falling than those who were not (Choi & Kim, 2007). Moreover, the central nervous system drugs, especially psychotropics (Hartikainen, Lönnroos, & Louhivuori, 2007; Lee et al., 2008; Panel on Prevention of Falls in Older Persons, American Geriatrics Society and British Geriatrics Society, 2011), antiarrhythmic drugs, antiparkinson drugs (Baranzini et al., 2009), antidepressants, and anti-anxiety drugs (Sterke et al.) were reported as the factor that contributed to increasing the risk of falling. These results suggest that the nursing intervention programs designed to regulate medication usage are needed in order to prevent falls.

In this study, 27.8% of the participants had experienced falls during the preceding year and 52.2% had experienced falls more than a year ago. Hong and colleagues (2010) reported that the occurrence rate of falls among adults over 45 was 4.0%, while that among adults over 65 was 6.3%. Albeit relatively lower than the results of this study, these findings indicated that the elderly over 65 were more likely to experience falls than those aged 45–64 years. Several earlier studies have reported that the elderly who has experienced at least one fall is more likely to experience subsequent falls (Pluijm et al., 2006; Stalenhoef et al., 2002).

The findings also revealed that winter and the afternoon harbored the greatest possibility for the occurrence of falls. Since the results of this and another study (Lim et al., 2010) indicated that the incidence of falls is proportional to the amount of activity, it is important to link seasonal or temporal factors to the causes of falls, rather than examining them in isolation. The cause of falls most prominently observed in this study was a slippery or uneven floor (26.3%); in terms of location, falls were seen to occur most frequently in rooms (43.8%). Hence, we can conclude that both internal and external environments, especially the condition of the floor or ground, have an important effect on the incidence of falls. Because such factors are also connected to the season, time of day, and place, there is an urgent need to make the environment safer for the elderly both within and outside the home, with particular attention paid to floor-finishing and ground-paving materials.

Table 4 *Physical Endurance, Flexibility, Motor Agility and Dynamic Balance, and Static Balance Test*

Variables	Test items	Faller ($n = 99$) M (SD)	Nonfaller ($n = 257$) M (SD)	t	p
Physical endurance	2-min step test (sec)	84.74 (25.41)	89.53 (23.04)	1.66	.097
Upper body flexibility	Back scratch (cm)	−3.32 (2.27)	−4.78 (3.90)	1.13	.258
Lower body flexibility	Chair sit-and-reach (cm)	11.04 (7.11)	11.14 (8.11)	.041	.967
Motor agility & dynamic balance test	244 cm up-and-go (sec)	3.55 (2.72)	4.01 (2.54)	1.52	.130
Static balance test	Tandem stand with eye opened (sec)	16.03 (6.87)	17.74 (5.21)	2.23	.028*
	Tandem stand with eye closed (sec)	8.28 (6.74)	10.59 (7.12)	2.84	.005*
	One leg with eye opened (sec)	12.38 (7.51)	12.94 (7.27)	.634	.526
	One leg with eye closed (sec)	4.94 (3.70)	4.99 (3.39)	.090	.929

*$p < .05$.

In this study, PF tests were taken to evaluate muscle strength, physical endurance, flexibility, motor agility and dynamic balance, and static balance. The results were compared between the faller and the nonfaller group. When upper-body muscle strength was evaluated, the faller group exhibited inferior muscle strength in flexing and extending the elbow joint, thus showing that the faller group had weaker upper-body muscle strength than the nonfaller group. Previous studies that used grip strength to evaluate differences in muscle strength between fallers and nonfallers (Chang & Kang, 2004; Choi, 2009; Hong et al., 2010) have similarly reported that upper-body muscle strength is lower in the faller group than in the nonfaller group. According to Hong et al., those having weak grip strength, more often had trouble in daily living activities and falls, leading to serious injuries requiring medical treatment.

This study compared and analyzed lower-body muscle strength in detail by dividing it into hip, knee, and ankle strength. The majority of previous studies (Chung & Choi, 2009; Sung, Kang, & Lee, 2007) have performed lower-body strength assessments by measuring the muscle strength of the knee. These studies have reported that muscle strength and muscular endurance are lower among fallers than among nonfallers. The aforementioned results demonstrate that both the flexion and the extension of the knee are related to falling. The present study found that the faller group fell below the nonfaller group in all categories of upper-body muscle strength. As for the lower-body, muscular strength associated with the right and left hip flexion, right and left knee extension, left ankle planter strength, and left ankle inversion was lower in the faller group. Moreover, in the case of elbow flexion and knee extension, the measurements of physical strength among elderly women aged over 75 demonstrated that stronger muscle strength lowered the frequency of falls that leads to fractures of the legs or arms (Sipilä et al., 2006). This suggests that both upper- and lower-body muscle strengths are the factors associated with falls. In an ankle evaluation, a statistically significant difference was found only in the left ankle muscle strength, but this finding appears to be linked to the left- or right-footedness of the participants. Accordingly, providing individually customized exercise programs reflecting the foot favored by the elderly will contribute to minimizing the incidence of falls.

When the Tandem Stand test was used to compare static balance, these results appeared to have a statistically significant difference showing an inferior static balance among fallers. According to Wallmann (2001), the Sensory Organization Test that assessed the patient's ability to balance using 6 trial conditions found that the faller group lacked the ability to maintain balance than the nonfaller group. This was especially the case with tests that measured the time it took for the subject to maintain an upright stance with as little sway as possible without changes in the peripheral vision, similar to the Tandem Stand adopted in this study; static balance was lower in the faller group than in the nonfaller group.

Previous studies have reported that the faller group exhibited less balance than the nonfaller group (Sung et al., 2007), with the ability to maintain balance diminishing as fall frequency increased (Choi et al., 2007), and that the elderly with fall experiences felt dizzy more often in everyday life than those without fall experiences (Chang & Kang, 2004). The elderly who have fallen in the past perform movements with relatively less stability than those with no fall experience; they also take more time to complete a movement than their nonfaller counterparts (Kim & Shin, 2005). Both factors serve to lessen physical responsiveness. In addition, the faller group showed an increased mediolateral sway (side to side) in a narrow balance stance compared to the nonfaller group (Melzer et al., 2004), which indicated that the faller group was weaker in maintaining balance. In addition, the recurrent faller group displayed greater posture imbalance in the visual and proprioceptive conditions, took more time to sit or stand without assistance, and walked at a slower pace than the nonfaller group. Thus, it is essential to assess the neurologic risk factors for falls among recurrent fallers (Lázaro, González, Latorre, Fernández, & Ribera, 2011).

Judging from the findings of the preceding studies and this study, exercise program strategies for improving the static balance of the faller group are necessary. Oh and Park (2010) have concluded that the elderly who have difficulty in keeping balance tend to use more hip muscle than ankles, resulting in a higher risk of falls. Thus, exercise training program for enhancing ankles and overall lower-body muscle strength is effective in helping to maintain balance. Since balance affects the occurrence of falling and is closely linked to muscle strength, fall-prevention strategies should promote the enhancement of both balance and muscle strength.

Previous studies have found that exercise programs enhancing balance and strength were the one of the effective interventions for fall prevention among old adults (Bird et al., 2009; Schoenfelder & Rubenstein, 2004). Moreover, the Panel on Prevention of Falls in Older Persons, American Geriatrics Society, and British Geriatrics Society (2011) have reported that it was more effective when the exercise program was applied with other intervention programs; the panel mentioned that applying an exercise program 1–3 times a week for more than 12 weeks at varying intensities produced positive results. Thus, to achieve the desired effects, the period and the method of the intervention program need to be considered.

In addition, since community nurses are not exercise professionals, it may not be easy to induce them to educate the elderly and constantly execute various exercise intervention programs for enhancing various physical functions to prevent falls. However, community nurses should make efforts to implement those programs (e.g., exercise program focused on physical fitness enhancement, fall risk factor managements) on community-dwelling old adults for fall prevention. Schoenfelder and Rubenstein (2004) have suggested that nurses can easily train and teach an exercise program since even a simple exercise plan, such as ankle strengthening or walking exercises, might have positive influence on the results related to the occurrence of falls, including balance or fear of falling. Therefore, community nurses need to suggest a variety of practical strategies for fall prevention, such as education and exercise programs, in order to improve the overall physical functions of the elderly, including muscle strength and static balance in daily life, by utilizing sufficient knowledge on various intervention plans, such as fall-prevention exercise.

This study selected and divided participants into the faller and the nonfaller groups, based on the answers obtained by self-report on the recent experiences of falls in the past year. There are limitations to evaluating and making a broad interpretation of the results on the differences in PFs caused by the experience of falls between the two groups. Moreover, a subgroup analysis of time-frame captured fall events was not performed; various PF test methods were not compared and analyzed when assessing PFs related to the occurrence of falls. Additional limitations are that this study was unable to measure inter-rater reliability for among examiners in evaluating physical functions and that using multiple t test data analysis methods to compare the faller and nonfaller groups would lead to type 1 error.

Conclusion

In this study, we revealed that upper body muscle strength used for elbow flexion and extension, lower body muscle strength linked to both hips flexion, both knees extension, left ankle plantar flexion and left ankle inversion, and static balance of tandem standing with eyes opened and closed showed significant differences between the faller and nonfaller groups.

Based on these findings, we suggest the following. First, community nurses should recognize the important risk factors, such as polypharmacy, environmental hazard and make efforts to manage those factors. Second, community nurses should recognize physical function abnormality such as static imbalance, lower limb weakness and implement exercise intervention program to enhance the older adults' physical function. Third, we need to take the characteristics of participants' needs into consideration when developing customized fall-prevention protocols and applying it to allow community nurses to provide various fall-prevention interventions, including education and exercise programs. Last, further research is needed to ascertain the factors related to falls in the faller group and the nonfaller group through a subgroup analysis of time-frame captured fall events.

Conflict of interest

The authors declare no conflict of interest.

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